Dual side cooling package DSOP
Advance: Thermal conductance innovation for Power-MOSFET
Dual side cooling package DSOP Advance: Thermal conductance innovation for Power-MOSFET

A new MOSFET package called DSOP Advance (Dual Side Cooling SOP 5x6mm) has been developed. That device features an innovative thermal conductance with dual side cooling realized by using a Copper (Cu) plate on the bottom and on the top package surface. Compared with the single side cooling package structure, the thermal resistance ($R_{th}$) could be reduced by 26% and the avalanche energy could increase as well due to the thermal conductance improvement. Also, a 25% reduction of the package electrical resistance could be achieved, due to the conductive path cross-sectional area increase.

Introduction

Low-voltage power MOSFETs are used as main switching devices in power supply systems. The power density of these systems is increasing continuously. In order to reduce the system volume and power loss, a significant improvement of the package heat radiation of the MOSFETs is necessary. The reduction of the power loss has been achieved by decreasing the device on-resistance and parasitic capacitances. However, the heat radiation performance improvement of the MOSFETs has been limited by the package structure. For example, the conventional single side cooling MOSFETs are usually mounted with cooling fins as shown in Figure 1. In such a case, the heat dissipation between the devices and the fins is blocked by the insulated mold of the package surface. Therefore, larger cooling fins are necessary for effective heat dissipation. In order to solve this problem, we have developed a new high heat dissipation MOSFET package called DSOP Advance as shown in Figure 2, which is adopting a dual cooling technology. This paper demonstrates an innovative heat radiation performance and low package electrical resistance of the DSOP Advance.

![Figure 1 – Typical implementation of the single side cooling MOSFETs.](image)

![Figure 2 – Structure of a new MOSFET package: DSOP Advance](image)
The design and electrical characteristics of the DSOP Advance

1. Package structure
The conventional single side cooling 5x6mm MOSFET called SOP Advance (Figure 1) is covered with an insulating mold. Therefore, the heat dissipation path of the package is mainly its bottom drain side cooling plate. On the other side, the DSOP Advance package has a top source side cooling plate in addition to the bottom drain side plate as shown in Figure 2. These cooling plates contribute in reducing the thermal resistance (Rth). Figure 3 shows the difference between the proposed DSOP Advance package cross-sectional view compared to competitor’s dual side cooling package and the single side cooling package (SOP Advance) [1][2]. The competition dual side cooling package has an independent Cu radiation plate on top of the Cu connector as illustrated on Figure 3. Such a structure includes therefore interfacial thermal and electrical resistances between the Cu radiation plate and the Cu connector. In comparison, the DSOP Advance package is adopting only one integrated connector. So, there are no additional interfacial thermal and electrical resistances. In addition, low manufacturing cost is expected due to the reduction of the number of components.

![Integrated connector](image1)
![Stacked connector](image2)
![Interfacial resistance](image3)

a) TOSHIBA's dual side cooling
b) Competitor's dual side cooling
c) Single side cooling

Figure 3 – Cross-sectional package structures of a) TOSHIBA’s dual side cooling, b) Competitor’s dual side cooling, c) Conventional single side cooling.

2 Thermal and electrical characteristics
The thermal resistance of the DSOP Advance and conventional single side cooling structure with heat sink were estimated. The Rth of the DSOP Advance was 26% lower compared to conventional single side cooling structure as shown in Figure 4. That is due to the thermal conductance enhancement of the top side.

We estimated the magnitude of interfacial thermal conductance between competition and DSOP Advance. Against the competition dual side cooling package a 50% lower top cooling plate Rth could be demonstrated as shown in Figure 5.

In addition, the $R_{th}$ is reduced not only on the static $R_{th}$ region but also in the transient short pulse region. The reduced transient $R_{th}$ could contribute to improve avalanche energy. Figure 6 shows the avalanche energy comparison between the conventional single side cooling package and the DSOP Advance. The avalanche energy of the DSOP Advance was improved by 13% compared with the conventional single side cooling package.

Following thermal characteristics, electrical resistance was estimated. Figure 7 shows the comparison between the on-resistance of the conventional single side cooling package, DSOP Advance and the competitor. The package electrical resistance of the DSOP Advance was reduced by 25% due to the thick Cu connector of DSOP Advance. The combination of the latest generation chip (UMOSIX-H) and the DSOP Advance package achieved best in class lowest $R_{DS(ON)}$. Figure 8 shows the drain current dependence of the channel temperature without heat sink. The DSOP Advance could suppress channel temperature rise.

The difference between two curves comes from package electrical resistance difference. Figure 9 shows our $R_{DS(ON)}$ roadmap of the combination of the chips and packages. We will continue to reduce the $R_{DS(ON)}$ with both package and Si technologies.
Figure 7. $R_{DS}(\text{ON})$ ($V_{GS}=10\text{V}$) comparison among combinations of Si chips and packages.

Figure 8. Channel temperature comparison between single side cooling and dual side cooling. Reduction of package resistance contributes to reduce channel temperature.

Figure 9 – $R_{DS}(\text{ON})$ roadmap of chip generation and packages.
Summary

This paper has presented a new dual side cooling MOSFET package which is called DSOP Advance. By adopting the thick Cu connector, 26% outstanding thermal resistance reduction and 25% package electrical resistance reduction were achieved. The excellent thermal resistance of the DSOP Advance enables to reducing the size of external radiating fin. Also the best in class new power MOSFET using UMOSIX-H with DSOP Advance was presented. Such devices contribute to reducing system volume and increasing system power density.

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